FACTORS AFFECTING MATERIAL WASTE ON CONSTRUCTION SITES IN NIGERIA

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ABSTRACT

Ineffective planning and control of materials on sites could lead to poor performance and undesirable project outcomes as well poor public image of construction industry. This study assesses the level of contribution of several factors to construction material waste generation. Structured questionnaires were administered to two groups of stakeholders in construction industry. Relative contribution index, Mann-Whitney U and Kruskal-Wallis tests are used to analyse the data collected. The first three highest contributors to material waste are found to be reworks due to non-conformance to specifications, waste from cutting uneconomical shapes, and design changes and revisions with average relative contribution index of 0.801, 0.791 and 0.773 respectively. The findings revealed that there was no significant difference between the perceptions of consultants and contractors; and there was no location effect in the level of contribution of the assessed factors to material waste generation as perceived by the respondents from different locality with a p-value of 0.469. With all the factors being scored with relative contribution index greater than 0.600; it is concluded that material waste generation is a critical and complex issue in Nigerian construction industry. The study recommends that all stakeholders in the construction industry should jointly consider waste minimisation strategies to reduce the level of waste generated on site.

KEYWORDS*: Building sites; consultants; contractors; material waste; relative contribution index; Nigeria.*

1.0 INTRODUCTION

The increasing quantities of waste have created a bad image for the construction industry. In addition, an ineffective planning and control of materials on sites could lead to poor performance and undesirable project outcomes (Jayamathan and Rameezdeen, 2014). Nevertheless, the economic impact, contributions to employment and the benefits of investment in construction industry are very enormous. Construction activity forecasts the general direction of an economy and for this reason the industry is often described as a leading economic sector. The Nigerian construction market is among the largest construction markets in Africa, which has recorded impressive growth over the years. In 1981, it accounted for 5.8% of Nigeria's GDP (Oluwakiyesi, 2011). Notwithstanding, construction activities result in the depletion of limited natural resources. According to Horvath (1999), the construction industry is one of the largest and most important industries, being at the same time the main consumer of natural resources and one of the largest polluters.

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Construction material contributes significantly to the cost of construction project; therefore, material wastage has adverse impact on construction cost, contractor's profit margin, construction duration and can be a possible source of dispute among parties to a project (Enshassi, Mohammed and Abushaban, 2009; Fellows, Langford and Newcombe, 2002). The cost of material waste generated on building sites represents avoidable cost in construction which can either be eliminated or reduced. Hoe (2005) stated that the extent to which waste can be prevented in the construction industry has been a long-debated issue. Whereas it is impossible to completely eliminate all wastage, the concern should be how practices in the local industry can be managed to minimise waste. The cost reduction achieved by preventing the generation of construction waste is equally of direct benefit to all stakeholders on a construction project.

There are very few local studies about construction waste in Nigeria. Olomolaiye, Wahab and Price (1987) discovered 43 percent unproductive time on construction sites in Nigeria while Olomolaiye (1991) asserted that excessive materials wastage in Nigerian construction industry was due to improper management. Akinkurolere and Franklin (2005) observed that manual labour is more extensively employed in most Nigerian construction firms in handling and transportation of materials including the fragile ones and the belief that the cost of recycling and reusing of waste is prohibitive. Dania *et al*. (2007) reported that site waste management is very poor. Akanni (2007) found 13.6 percent wastage level of material in Nigerian construction industry. Oladiran (2009) discovered that 36.7 percent of professionals in construction companies rarely use waste management plans while 13.3 percent never used it. Furthermore, Adewuyi, Idoro and Ikpo (2014) revealed that the levels of material wastes generated on site are in excess of estimator's allowance for some materials studied. Therefore, this study surveyed the problems of construction material waste in Nigerian construction industry using seventy factors carefully selected from previous literatures and four new factors resulting from peer view discussion to investigate their contributions to the aforementioned problems bearing the following objectives in mind:

i. Evaluation of the level of contribution of the identified factors to material waste generation on construction site;
ii. Determination of the aggregate contribution of the variable group (group of factors derived from the same source) to material waste;
iii. Comparison of consultants' and contractors' perception of the level of contribution of the selected factors to material waste generation on site; and
iv. Determination of variation among the perceptions of consultants, contractors and the combination of the two groups across the six States of South-South, Nigeria.

2.0 CONSTRUCTION WASTE GENERATION

There have been different definitions of construction material waste by different authors. For the purpose of this study, construction waste is viewed as construction materials that are lost in transit on or off site, discarded without adding value to the project for which it was procured including overproduction or left over from newly constructed facility.

The causes of construction material waste can be measured and evaluated using a large number of construction phase related factors such as design and documentation, materials procurement and management, operations, environmental conditions, site management practices and site supervision (Gavilan and Bernold, 1994; Bossink and Brouwers, 1996; Faniran and Caban, 1998; Ekanayake and Ofori, 2000). The first set is related to designers and client's requirements; the people who consider the functional requirement of the building. The second set is related to construction team and contractors; people who consider the buildability and maintainability of the building. The third set is related to the site supervisors and the site operatives; people who are directly involved in the art of putting the raw materials together to form the building envelop.

Gavilan and Bernold (1994) considered 12 factors as main causes of construction waste generation. The study pioneered the grouping of such factors into various categories. Bossink and Brouwers (1996) measured the level of material waste generation using 31 factors in their study to determine the sources and causes of construction waste. Ekanayake and Ofori (2000) examined and discussed 27 factors as causes of construction waste. According to Poon, Yu and Ng (2001), research in Hong Kong indicates that there are 13 factors that cause material waste in construction. Garas, Anis and El Gammel (2001) considered 10 important factors in the generation of construction waste in Egyptian construction industry. Alwi, hampson and Mohamed (2002) and Formoso, Soibelman, Cesare and Isatto (2002) considered 31 and 11 factors respectively in their studies of causes of waste in construction. Polat and Ballard (2004) assessed 14 factors in his study to identify the main causes of material waste in the Turkish construction industry. Al-Moghany (2006) appraised 92 factors which cause material and time waste in construction in Gaza Strip.

Most of the available literature mix up or combined the factors affecting material waste with those affecting time waste. Therefore, this study scrutinised the available literature meticulously and extracted seventy (70) factors responsible for waste of materials on building sites. The identified factors were sorted into groups and arranged according to their respective sources. The source of a cause or factor of waste generation is perceived as the origin from which the said cause or factor is derived or conversely a group of causes/factors are treated as subset of a source from which they originate. Four (4) new factors, based partly on peer view discussion and partly on peculiarities of the study area, are added to the list of the identified ones. These include government authority's instruction and policy, supplier's non-involvement, restiveness and contractor's non-involvement. Furthermore, the five main sources were modified to produce eight sources vis-a-vis: design and documentation, materials management on site, material procurement, material handling, storage and transportation, on-site operations, environmental conditions, site management and practices, and site supervision.

3.0 METHODOLOGY

A questionnaire survey was used to elicit the perceptions of consultants and contractors, for a period of six months, about the factors affecting the generation of material wastes on building site in the South-South zone of Nigeria comprising six States (Akwa Ibom, Bayelsa, Cross River, Delta, Edo and Rivers). Questionnaires were sent to randomly selected consultants and contractors. The selection of consultants and construction contracting firms for this study was based on probability sampling, using the stratified random sampling technique. This is because the study used a segment (South-South) of the country's construction population with only consultants and contractors, among many stakeholders in the construction industry. Additionally, the population of the study is distinctively classified into six groups according to six States in South-South of Nigeria. The population of respondents were identified from the listings (registers) of public clients; with small and medium sized building firms being the target of the study. The breakdown of the population size for each category is shown in Table 1.

Table 1. Population frame of the Study

Category	**Akwa Ibom**	**Bayelsa**	**Cross River**	**Delta**	**Edo**	**Rivers**	**Total**
Consultants	75	60	52	81	93	71	**432**
Contractors	162	145	119	108	102	156	**792**

The sample size for this study was determined using the Taro Yamane formula for finite population as stated in Equation 1 (Udofia, 2011).

$$n = \frac{N}{1+N(e)^2} \tag{1}$$

where:

n is the sample size;
N is the finite population;
e is the level of significance; and 1 is unity.

The relative contribution index method (RCI) was used to analyse the respondents' perceptions of the level of contributions of the identified factors to material waste generation on site. The RCI was computed as shown in Equation 2:

$$\text{Relative contribution index (RCI)} = \frac{\sum W}{A*N} \tag{2}$$

where:

W is the weight given to each factor by the respondents and ranges from 1 to 5;
A is the highest weight = 5; and
N is the total number of respondents.

The respondents were requested to indicate, based on their local experience, the level of contribution of each of the 74 factors to construction material waste generation on a five-point Likert scale namely: nil, low, moderate, high and very high. The questionnaire was validated by the criterion-related reliability test which measures the Cronbach's alpha coefficient (which ranges from 0.792 to 0.977) between the factors affecting the generation of waste on building construction projects using statistical inference validity and external validity test.

The aggregate relative contribution index (ARCI) of each group of factors was determined to establish the levels of contribution of each group to material waste generation. It is noted that the number of variables in each group varies because the number of variables in each group (source) may not be exhaustive enough to embrace all accruable factors from such source. This may give advantage to the groups with more factors over the ones with lesser numbers in their comparison. These limitations should be accounted for and accommodated as a good practice to reduce biasness of the result. Therefore, weighting method was employed to calculate the appropriate scale factor for each group. The scale factor is derived as the ratio of the total number of the study variables (factors) to the number of variables in the group under consideration as express in Equation 3.

$$S_i = \frac{V_t}{v_i} \tag{3}$$

where:

S_i is the scale factor of the i^{th} group;

V_t is the total number of the study variables ($V_t = 74$);

v_i is the number of variables in the i^{th} group.

Having derived the scale factor, the summation of the RCI for each group is obtained and the ARCI determined by the product of the two (ARCI = Si *ΣRCI). The aggregate contribution of the factors in each group to material waste generation were derived and subsequently ranked.

Two hypotheses, derived from the last two objectives, were posited for the study as follows:

- H_1: There is no significant degree of agreement between the perceptions of contractors and consultants.
- H_2: There is no significant variation among the contributions of the factors to material waste in different locality.

To determine the significant difference between the perceptions of the two groups, Mann-Whitney U test is used while the variation among the perceptions of consultants and contractors (separately) across the six States selected for the study is tested with the use of Kruskal-Wallis test at $p \geq 0.05$ (95% level of significance). Additionally, the perceptions of consultants and contractors were combined for each State and possible variation among them tested with the latter statistical tool. The rule for the rejection of the hypothesis is that when the p-value > 0.05, the test fails to reject the hypothesis, however, when the p-value ≤ 0.05, the test rejects the hypothesis.

4.0 RESULTS AND DISCUSSION

Table 2 shows the descriptive breakdown of the questionnaires administered and the response rate with the equivalent percentages. A total of 949 questionnaires were distributed as follows: 363 to consultants and 586 to contractors. A total of 743 questionnaires were received with a response rate of 78% as follows: 288 (79%) from consultants and 455 (78%) from contractors as respondents as shown in Table 3. The respondents were experienced construction project managers, site engineers/office engineers, and organisations' managers (with average experience of 15 years in the construction industry). The factors considered in this study were listed under 8 groups based on the literature reviewed with slight modifications. The modifications are necessitated by the overlaps of the variables in some groups in previous studies reviewed. The selected factors are ranked and discussed on the basis of their respective group as follows:

Table 2. Descriptive results of the response to questionnaires administered

Study Area	Questionnaire Administered No	Questionnaire Returned No	Respon se Rate (%)	Questionnaire Discarded No	(%)	Questionnaire used for the study No	(%)
Consultants							
Akwa Ibom	63	55	87.30	2	3.17	53	84.13
Bayelsa	52	39	75.00	1	1.92	38	73.08
Cross Rivers	46	38	82.61	3	6.52	35	76.09
Delta	67	57	85.07	3	4.48	54	80.60
Edo	75	63	84.00	4	5.33	59	78.67
Rivers	60	52	86.67	3	5.00	49	81.67
Total	**363**	**304**	**83.75**	**16**	**4.41**	**288**	**79.34**
Contractors							
Akwa Ibom	114	99	86.84	3	2.63	96	84.21
Bayelsa	105	80	76.19	2	1.90	78	74.29
Cross Rivers	91	74	81.32	4	4.40	70	76.92
Delta	84	71	84.52	3	3.57	68	80.95
Edo	81	63	77.78	4	4.94	59	72.84
Rivers	111	89	80.18	5	4.50	84	75.68
Total	**586**	**476**	**81.23**	**21**	**3.58**	**455**	**77.65**

4.1 Design and Documentation factors

The RCI and rank of design and documentation group of factors is summarised in Table 3. Rework due to non-conformance to specifications is perceived by consultants and contractors to be the highest contributor to waste generation. The ratings assigned to this factor suggests that most of the building contractors in the study area are fond of engaging artisans who profess to be "experienced" instead of building professionals at the construction stage. The patronage of those so called experienced artisans, who cannot properly interpret drawings correctly nor understand the specifications required for different building elements may constitute a major source of waste as the client's representatives may not compromise their specifications. The waste arising from this factor may also be due to inadequate supervision, unclear instruction to workers, inadequate job planning, poor management, incompetence of contractor or subcontractor, late information from designers and a host of other related factors. Fayek, Dissanayake and Campero (2003) explored the causes of rework and identified about twenty factors showing that rework contributes significantly to waste generation on site.

Design changes and revisions is adjudged the second highest contributor to waste generation by the two groups with RCI of 0.785 and 0.760 respectively. The agreement between the two groups may be due to project scope changes, errors and omissions, poor document control and late design changes including late information on the part of designers or consultants.

Table 3. Relative contributions of factors affecting material waste on site

S/N	Factors	Consultants		Contractors	
		RCI	Rank	RCI	Rank
	Design and Documentation				
1	Design changes and revisions	0.785	2	0.76	2
2	Lack of attention paid to dimensions of product	0.651	13	0.673	9
3	Selection of low quality product	0.697	4	0.685	7
4	Ignorance about types and sizes of materials on design documents	0.666	8	0.67	11
5	Specifying materials and dimensions without considering waste	0.668	7	0.676	8
6	Complexity of detailing in the drawings	0.665	9	0.655	12
7	Waiting for design documents	0.672	6	0.71	3
8	Ambiguities, mistakes, and changes in specifications	0.66	11	0.638	14
9	Errors in contract documents	0.706	3	0.695	5
10	Incomplete contract documents	0.656	12	0.708	4
11	Ambiguities, mistakes, and inconsistencies in drawings	0.679	5	0.695	5
12	Reworks contrary to specifications	0.817	1	0.784	1
13	Contractor's non-involvement	0.628	15	0.582	15
14	Supplier's non-involvement	0.661	10	0.646	13
15	Manufacturer's non-involvement	0.643	14	0.673	9
	Materials procurement				
16	Poor schedule of materials procurement	0.623	7	0.654	7
17	Ordering of materials that do not fulfil project requirements	0.645	6	0.66	6
18	Incorrect estimated quantity	0.664	5	0.663	5
19	Over ordering or under ordering	0.7	2	0.681	2
20	Impossibility to order small quantities	0.698	3	0.666	3
21	Purchase of materials contrary to specification	0.713	1	0.699	1
22	Substitution of a material by a more expensive ones	0.673	4	0.665	4
	Materials management on site				
23	Damage of materials on site	0.677	6	0.669	8
24	Waste from uneconomical shapes	0.799	1	0.783	1
25	Unnecessary inventories on site	0.71	3	0.685	5
26	Overproduction	0.694	5	0.68	6
27	Manufacturing defects	0.676	7	0.679	7
28	Theft and vandalism	0.701	4	0.697	3
29	Poor quality of materials	0.674	8	0.692	4
30	Lack of on-site materials control	0.774	2	0.761	2
31	Poor storage of materials	0.663	9	0.633	10
32	Over-sized of building elements during execution	0.654	10	0.629	11
33	Using excessive quantities of materials more than the required	0.647	11	0.65	9
	Materials handling, storage and transportation				
34	Wrong handling of materials	0.648	6	0.657	8
35	Unnecessary material handling	0.698	1	0.694	2
36	Insufficient instructions about handling	0.626	14	0.634	12
37	Poor and wrong storage of materials	0.653	5	0.61	14
38	Inadequate stacking and insufficient storage	0.69	2	0.693	3
39	Insufficient instructions about storage and stacking	0.638	11	0.634	13
40	Inappropriate storage leading to damage or deterioration	0.635	12	0.65	10
41	Double handling of materials	0.674	3	0.713	1
42	Damage during transportation	0.658	4	0.68	4
43	Bad road condition	0.644	9	0.675	6
44	Accident	0.647	7	0.657	8
45	Inappropriate equipment	0.631	13	0.638	11
46	Breakdown of equipment	0.641	10	0.661	7
47	Poor technology/malfunction of equipment	0.647	7	0.679	5
	On-site operations				
48	Rework due to workers' mistakes	0.682	7	0.668	5
49	Damage to work done caused by subsequent trades	0.656	11	0.647	11
50	Use of incorrect material	0.699	2	0.664	8
51	Poor workmanship	0.691	3	0.69	2
52	Lack of skilled subcontractors	0.691	3	0.668	5

53	Difficulty in performance and professional work	0.666	10	0.659	9
54	Interaction between various specialists	0.689	5	0.683	3
55	Wrong construction method	0.672	9	0.666	7
56	Accidents due to negligence	0.678	8	0.651	10
57	Using untrained labours	0.733	1	0.709	1
58	Lack of coordination among crews	0.687	6	0.673	4
	Environmental conditions				
59	Severe weather conditions	0.713	1	0.705	1
60	Effects of subsurface conditions	0.683	2	0.699	2
61	Site conditions significantly different from contract documents	0.628	4	0.661	4
62	Restiveness	0.617	5	0.612	7
63	Labour unrest	0.608	7	0.629	5
64	Difficulties in obtaining work permits	0.613	6	0.622	6
65	Government authority instruction/policy	0.656	3	0.684	3
	Site Management and Practices				
66	Lack of waste management plan	0.658	4	0.662	1
67	Lack of a quality management system aimed at waste minimisation	0.679	1	0.656	3
68	Lack of strategy to waste minimisation	0.666	2	0.633	5
69	Poor site layout	0.663	3	0.636	4
70	Incompetent contractor’s technical staff	0.64	5	0.66	2
	Site Supervision				
71	Inadequate supervision	0.641	3	0.665	1
72	Incompetent consultant's resident engineer	0.662	1	0.658	2
73	Slow response from consultant engineer to contractor inquiries	0.644	2	0.653	3
74	Change orders	0.614	4	0.629	4

Number of respondents for consultants is 288 and for contractors is 455

Most often, there is lack of proper coordination of the project team of public client projects, especially government projects. Earlier studies by Faniran and Caban (1998), Alwi, Hampson and Mohamed. (2002) and Ekanayake and Ofori (2004) revealed that design changes is one of the most significant sources of construction material waste generation.

Errors in contract documents are ascribed the third highest position by the consultants but fifth by the contractors. Statistically speaking, there is no significant difference in the means of the two groups of respondents. A similar result was found by Ekanayake and Ofori (2000) where this factor was ranked in the eighth position among the causes of material waste on site.

Waiting for design documents and drawing is ranked third by contractors. This factor appears to be a subset of rework and conforming to issues of late information or instructions to contractors whereby some other type of material have been used for a constructed facility or procured other than the type specified in the documents received latter.

The aforementioned four factors are interrelated and interwoven. Closely related to these factors is an incomplete contract document; which is perceived to be the fourth highest contributor by the contractors but occupies the twelfth perceived position by the consultants. These factors may lead to waste where clients, especially public clients, for political reasons are much in a haste to commence project ahead of complete documents. The jobs executed before the drawings and documents are ready may not meet with the specifications thereby leading to rework.

4.2 Material procurement factors

The relative contribution index and rank of material procurement group of factors is summarised in Table 3. Purchase of materials that do not comply with specification is rated the most contributor to material waste generation by both the consultants and contractors among the factors in the procurement group. The use of purchased materials that do not comply with specification appears to be common among contractors who indulge in ‘cutting corners’ to reduce expenses on materials. This practice is common with public projects that are politically awarded through the influence of “god-fathers”. This is one of the evils of corruption found in the construction sector in Nigeria. The use of non-professionals on building sites and their non-involvement in purchase of materials may as well lead to waste. Al-Moghany (2006) found the same factor in the third position among the materials procurement group.

Over ordering or under ordering occupies the second highest position in the procurement group as perceived by the two groups of respondents. This may be due to lack of coordination between warehouse and construction crews or centralised purchasing. This is one of the characteristics of any typical engineering or production department where one purchase department or its single authority is authorised and made responsible to make all types of purchases for all the departments. Ekanayake and Ofori (2000) described the factor as ordering errors (too much or too little) where it was accounted to be the second highest contributor to material waste in procurement group.

Lack of possibility to order small quantities is perceived to be the third most important factor in this group. This factor may be significant in situations where materials are supplied in bulk like fine and coarse aggregates but the quantity of job to be executed is small. This may as well be applicable to purpose-made or imported materials which were procured in excess of quantities required in anticipation of preventing short supply, unavailability or reduction of associated costs in the event of insufficiency. The left over may lead to waste where it cannot be transferred to other project nor resold.

4.3 Material management on site factors

The RCI and rank of material management on site group of factors is summarised in Table 3. Waste from cutting uneconomical shapes is perceived to be the highest contributor to material waste by the two groups with RCI of 0.799 and 0.783 respectively. The traditional or in-situ method of construction prevailing in Nigeria and non-compliance with modular coordination principle, especially in terms of using non-standard dimensions, may be responsible for the respondents’ rating of this factor as the most important in this group. Secondly, it is observed that irregular shapes of design to achieve aesthetic appreciation of buildings are given more attention nowadays by both clients and designers and conformance to this demand may lead to excessive cutting waste. This type of waste is commonly found in timber, blocks, tiles and other materials supplied in sheets. The phenomenon of excessive waste from cutting uneconomical shapes has been reported by several authors (Adewuyi, 2012; Al-Moghany, 2006; Polat and Ballard, 2004; Enshassi, 1996) from different countries.

Lack of on-site material control is adjudged the second highest contributor to material waste generation in the group of factors that fall under material management on site. If a construction site is not manned by building professionals who understand practices of material management, materials may be poorly stored, double handling of materials may be prevalent, and material planning may not be given due attention. Transportation and handling of materials, being mostly manual among the categories of small and medium size construction firms as reported by Akinkurolere and Franklin (2005), may result to material wastage. For these reasons, the possibility of waste arising from lack of material control may be high.

Unnecessary inventories on site, which lead to waste, emerge in the third position as rated by the consultants but fifth by the contractors. Unnecessary inventories resulting from lack of resource planning or uncertainty of quantities estimation, might lead to waste by deterioration and losses due to inadequate stock conditions on site. Sometimes the relocation of stockpiled materials as a result of obstruction to construction operations results to waste where all the materials cannot be removed like aggregates or wastage occurring in double handling of blocks. Forsythe and Mate (2007) reported that the more re-stacking and barrowing of blocks the higher the expected breakages.

Theft and vandalism is ranked fourth by the consultants while it is ranked third by the contractors. A visit to one of the major construction company during this study revealed that some of the workers who indulge in the act of stealing cement are referred to as "cement rats". This factor has become a menace in the construction sector such that Berg and Hinze (2005) argued that theft and vandalism can be major cost components of a construction project because of their effects and associated problems. Theft and vandalism may lead to waste whereby part of materials like cement is stolen by partially opening the sack and was hidden for a period of time until the cement caked or about to be removed from store, being oblivious it was opened, and the content get spilled away leading to waste. Sometimes operatives cut reusable timber into their desired sizes to steal but could not for security reasons.

4.4 Materials handling, storage and transportation factors

The RCI and rank of material management on site factors are summarised and presented in Table 3. Double handling of materials occupies the first position by the perceptions of the contractors with RCI of 0.713 but third position based on the consultants' perceptions. Inadequate stacking and insufficient storage on site is ranked in the second and third positions by the consultants and the contractors respectively. These two factors are peculiar features of confined sites due to lack of adequate storage space, difficulties of transporting materials around site, work place becoming over-crowded, lack of adequate room for the effective handling of materials, damage occurring due to poor material management, and lack of adequate room to account for materials resulting to wastage of materials. On the other hand, some studies have also highlighted that large sites pose the biggest problems due to the long distances for which materials must be transported, coupled with the additional burden of monitoring materials. The common temptation among contractors is to set aside material storage areas around each building to satisfy their individual needs. This, however, will result in excessive material waste, extra material handling cost, and less manoeuvrability within the site (Sanad, Ammar and Ibrahim, 2008).

Inadequate stacking and insufficient storage can result from say when materials are stacked without pallets such as bricks/blocks or bags of cement; exposing materials to inclement weather such as steel bars which could rust and may get damaged; unpacked supply of materials like bricks, glass and tiles often increase wastage during transportation due to their fragile nature (Forsythe and Mate, 2007). This factor is perceived to be the second highest contributor to material waste by the consultants but third by the contractors.

4.5 On-site operation factors

Using untrained labours is ranked in the first position by the two groups of respondents in the on-site operations group of factors with RCI of 0.733 and 0.709 respectively as shown in Table 3. Untrained labour takes the form of hurriedly recruited labour or unskilled labour which suddenly metamorphosis into skilled ones and are imposed on contractors by localised pressure group. This is more notable in the study area due to youth restiveness. Furthermore, professional incursion (commonly referred to as quackery) can be regarded as using untrained labour and this is a common feature of the building industry in Nigeria. Zhongxi (2010) reported the use of untrained women workers during the construction of the overpass bridge at the China's fourth largest airport. Garas et *al*. (2001) and Alwi *et al*. (2002) found that untrained labour is one of the major contributors to material waste in Indonesian and Egyptian construction industries respectively.

Use of incorrect material is ascribed the second highest position as contributor to material waste among the on-site operations factors by the consultants but is ranked the eighth by the contractors. The disparity suggests that contractors do not simply agree to the issue of using incorrect materials. The disagreement may arise as a result of self-defence on the part of contractors but the practices of using incorrect materials among contractors might be a common knowledge to consultants. If the construction materials have already been purchased at the central store based on similar project executed in the past without due attention to details and specifications, waste might result if the materials cannot be resold or returned to the supplier. Similarly, if the management decided to keep the materials that are left over from newly constructed facility for future use or while negotiating the possibility of resale or return to supplier waste, may result while the materials last in the store.

4.6 Environmental conditions factors

Severe weather condition is ranked in the first position by both the two groups as presented in Table 3. The prevailing weather condition of the study area, being a zone that controls the north-south movement of rainfall in the tropics with mean annual rainfall of about 3250 mm as reported by Adejuwon (2012), may be responsible for the highest rating of this factor as a contributor to material waste among the factors in environmental conditions group by both the consultants and the contractors. Adewuyi (2012) revealed that severe weather is a significant factor in modelling construction material waste for the zone. Waste may occur due to this factor where the executed works are not properly protected against the weather effect, especially rainfall. Waste generated due to this factor may be beyond the control of site personnel.

Effects of subsurface conditions (type of soil, utility lines, water table) is ranked as the second highest contributor to material waste by the two groups of respondents as shown in Table 3. The common knowledge of the two groups on the erratic nature of the soils in this zone of the country; being a zone with protracted period of heavy rainfall in the year and pockets of waterlogged areas, may be responsible for the agreement.

4.7 Site management and practices factors

Lack of waste management plan is perceived as the most contributor to material waste in this group by the contractors while it is ranked in the fourth position by the consultants as shown in Table 3. It appears the contractors are quite aware of the benefits derivable from this document in curbing material waste generation on site while the consultants may not be too concerned about it because it is a document to be prepared primarily by and for the use of contractors. Incompetent contractor's technical staffs assigned to the project, as a contributor to material waste, is ranked in the second position by the contractors while it is ranked in the fifth position by the consultants' respondents. It suggests that the contractors place high premium on their technical staff with expectations to manage materials on site as compared to the ratings of the consultants.

4.8 Site supervision factors

Inadequate supervision is ranked in the first position in this group by the contractors while it is ranked in the third position by the consultants. The result suggests that contractors are of the opinion that with improvement on quality of supervision on site, and capable supervisors, the volume of material waste may be reduced. On the other hand, the consultants' perceptions seem to indicate that their roles and the qualities of their representatives on site are more significant to reduce material waste; since this group ranked the two factors involving their inputs on site in the first and second positions as shown in Table 3.

5.0 AGGREGATE RELATIVE CONTRIBUTIONS INDEX OF MATERIAL WASTE VARIABLES

To show the order of importance of the group of factors in their contributions to material waste generation, the summation of the relative contribution index (RCI) of the factors in each group was obtained for the two groups of respondents; the scale factor (S_i) calculated; and the product of the two parameters computed to arrive at the value of aggregate relative contribution index (ARCI) which are subsequently ranked. The order of rank of the group of factors is presented in Table 4.

Table 4. Ranking of ARCI of group of factors

Group of Factors	v_i	S_i	ΣRCI	ARCI	Rank
Materials management on site	11	6.73	15.23	102.48	1
Design and Documentation	15	4.93	20.50	101.08	2
On-site operations	11	6.73	14.92	100.43	3
Materials procurement	7	10.57	9.40	99.40	4
Materials handling, storage and transportation	14	5.29	18.41	97.36	5
Site Management and Practices	5	14.80	6.55	96.98	6
Environmental conditions	7	10.57	9.13	96.50	7
Site Supervision	4	18.50	5.17	95.57	8

v_i = number of variables in the ith group; S_i = scale factor of the ith group;

V_t =74; ARCI = Aggregate Relative Contribution Index

Material management on site is ranked in the first position as the most important group contributing to the generation of material waste on site. This may be due to non-engagement of competent personnel with relevant education to man the building production activities on site as reported by Olomolaiye (1991).

Design and documentation group is ranked in the second position. The common phenomenon to government projects where there is prevalence of project scope changes, poor document control and lack of effective project management, especially with respect to cost and project duration, may contribute to the level of material waste generated by this variable group.

On- site operations is ranked in the third position by the respondents. The variables in this group are directly the activities of the contractor's personnel which if managed very well may reduce waste and vice versa. Material procurement factor group is ranked in the fourth position. It suggests that material procurement practices need improvement in the Nigerian construction industry to reduce the volume of material waste generation. It summarily implies that some groups of factors may contribute more to material waste than others, suggesting that stakeholders in the construction industry should focus on the on the more important group without neglecting the others.

6.0 DEGREE OF AGREEMENT BETWEEN RESPONDENTS GROUPS

To explain whether there is significant difference in the perceptions of the two groups, Mann-Whitney U test is used at $p \geq 0.05$ (95% level of significance) as a measure to test hypothesis one, H_1. The test was carried out on each of the group of factors contributing to construction material waste and for all the factors combined together. Hypothesis one states that there is no statistical significant degree of agreement between the perceptions of contractors and consultants. The rule for the rejection of the hypothesis is that when the p-value > 0.05, the test fails to reject the hypothesis, however, when the p-value ≤ 0.05, the test rejects the hypothesis. The results of the test are presented in Table 5.

For each of the group independently, and all groups combined, the p-values are greater than 0.05; indicating that there is no significant difference between the perceptions of the two groups of respondents. Hence hypothesis one, H_1, is accepted and conclusion is drawn that there is no significant difference between the perceptions of consultants and contractors.

Table 5. Results of Mann-Whitney U test

Waste Variable Group	N	Z(critical)	Z (calculated)	P-value	Decision
Design and Documentation	15	64	-0.706	0.480	Accept
Materials procurement	7	8	-0.512	0.680	Accept
Materials management on site	11	30	-0.427	0.669	Accept
Materials handling, storage and transportation	14	55	-1.243	0.214	Accept
On-site operations	11	30	-1.843	0.065	Accept
Environmental conditions	7	8	-0.832	0.405	Accept
Site Management and Practices	5	2	-1.467	0.142	Accept
Site Supervision	4	0	-0.866	0.386	Accept
All groups combined	74	127	-0.167	0.867	Accept

7.0 DEGREE OF VARIATION AMONG RESPONDENTS FROM DIFFERENT LOCALITY

To establish if there is location effect on the contributions of the factors to material waste generation; hypothesis two (H_2), which states that there is no significant variation among the contributions of the factors to material waste in different locality, was tested with the use of Kruskal-Wallis test at $p \geq 0.05$. The result is presented in Table 6. The test reveals that there is no significant variation in the contributions of the identified factors to material waste as perceived by both the consultants and the contractors in different locality; hence, hypothesis two was accepted. It follows therefore that location has no effect on the contributions of the identified factors to material waste generation on site.

Table 6: Results of Kruskal-Wallis test

		Consultants			Contractors			Combined		
Location	N	Mean Rank	P-value	Decision	Mean Rank	P-value	Decision	Mean Rank	P-value	Decision
Akwa Ibom	74	235.57			242.91			238.44		
Bayelsa	74	231.40			224.93			225.95		
Cross River	74	200.14	0.221	Accept	197.20	0.295	Accept	199.68	0.469	Accept
Delta	74	206.61			237.01			218.91		
Edo	74	245.15			213.75			235.87		
Rivers	74	216.14			219.22			216.16		

8.0 CONCLUSION

Several factors can contribute to construction material waste. This study provides evidence on the level of contribution of each of 74 factors to material wastage in Nigerian construction industry. Notable among the most important factors are: reworks due to non-conformance to specifications, waste from cutting uneconomical shapes, lack of on-site material control and design changes and revisions. This study reveals that there is no significant difference between the perceptions of consultants and contractors about the contribution of the factors in each of the eight groups. Furthermore, the assessment of the factors shows that there is no variation among the six different locations where the perceptions consultants and contractors were sought with respect to their contributions to material wastage as reflected by the results of Kruskal-Wallis tests. It is noticed that all the factors were scored with RCI > 0.600; indicating that all the factors are important. Hence, it is concluded that material waste generation is a critical and complex issue in the Nigerian construction industry.

In view of the findings, this study recommends that all stakeholders in the construction industry, clients, designers, consultants, contractors, operatives and subcontractors, should jointly consider the use of waste minimisation strategies to reduce the level of waste generated on site. Trained personnel for monitoring the flow of materials should be employed in every construction firm. Training programme should be provided by contractors for the operatives about the proper handling, storage and transportation of materials on site. Government should promote the use of site waste management plan (SWMP) so that from the inception of the project, contractors can plan on how to manage the waste generation.

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